Marine Telepresence System

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Problem statement

In this thesis a telepresence system for marine applications will be presented. The main idea is to use a head mounted display of the type Oculus Rift to gain an improved presence while operating a Remotely Operated Vehicle (ROV).

Operating ROVs is hard. Especially when combining the use of a manipulator arm and maneuvering the ROV at the same time. This demands great skill from the operator. The hope is that with this kind of system, operating a ROV will be more like operating a land based excavator.

Before understanding how this concept works it is important to have some understanding of the technology involved and some terminology.

Oculus Rift is the name of the head mounted display used in this thesis, as seen in Figure 1. The Oculus Rift is equipped with sensors that captures the operators head movement, this is combined with display that encloses the entire view of the user.

Figure 1: Oculus Rift DK2 (Oculus 2014)

Usually the Oculus Rift system is used as a virtual reality (VR) platform.

- Virtual reality is defined as a computer generated three dimensional environment that can be interacted with in a real or seemingly real way by a person using electronically equipment. Typical VR applications include video games and simulators.
- Telepresence is defined as the use of virtual reality technology to control distant machinery or apparently participate in distant events. In this case presence and control of a ROV.

This is combined with the theory on modeling and control of ocean vehicles, so that the vessels involved will maneuver based on the operators head movements. For example in one of the implemented control modes, the ROV moves forward as the operator tilts his head forwards (pitch), sideways as the operators head is tilted sideways (roll) and turns as the operator turns his head.

To better understand what how this works, please see the demo of the system as implemented on the model vessel Cybership Enterprise 1 by Valle (2015).

Main Contributions

- A software that shows a live video feed on the Oculus Rift video system, while sending the Oculus Rift sensor data to a control system.
- A guidance system based on joystick control with position feedback. That takes the measurements from the Oculus Rift and turns it into desired position and velocity
- Model scale tests in the Marine Cybernetics laboratory with the model Cybership Enterprise I. Including the development of the of a new control software setup.
- Full scale tests with NTNUs ROV Sub-fighter 30k. Implementation of Oculus Rift as an input device on in the AUR-lab control system for ROVs.

Experimental platforms

As stated in the introduction the main goal is to make a ROV telepresence system. However, more platforms has been used in the design process.

Simulations, hardware-in-the-loop testing and models scale test have been conducted. Model scale tests has been conducted with the model vessel Cybership Enterprise 1 (CSE1) (see Figure 2), which is based in the Marine Cybernetics (MC) lab. It was built and commissioned by Skåtun (2011) before it was remodeled with a new control system this year as a part of the subject TMR4243 - Marine Control systems 2. The MC lab has equipment for position measurements which is critical when design feedback control systems for ocean vehicles. And the hardware setup is similar to what is used on the NTNU ROVs with National Instruments equipment.

Figure 2: Cybership Enterprise 1 (CSE1)

Figure 3: ROV SF 30k

Full scale tests has been conducted with the ROV SF 30k as seen to the right in Figure 3. This a working class ROV owned by NTNU. It runs the AUR lab control system presented by Dukan (2014) and is operated from the vessel R/V Gunnerus.

Control Theory

For the mathematical modeling and control theory of this system it will not be presented in detail here. Modeling and control theory for ocean vehicles are well described by Fossen (2011), while specific models and controllers for CSE1 and SF 30k are described by Skåtun (2011) and Dukan (2014). Since the contribution from this with regards to control theory is a the gesture based guidance, this will be presented more closely.

Gesture Based Guidance

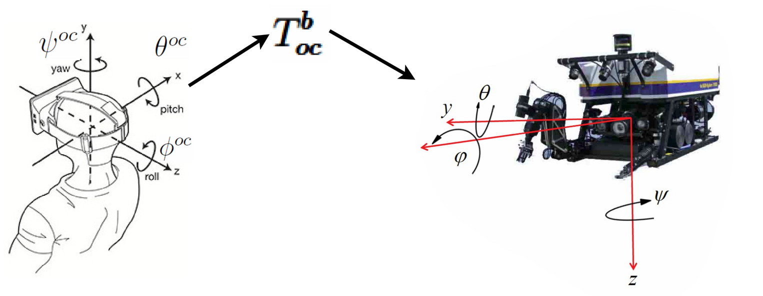

Figure 4: Transformation between Oculus Rift frame and ROV body frame

The main task of the guidance system is to transform the Oculus Rift sensor data into a feasible velocity reference for the vessel to be controlled. The design is based on the setup for joystick control with position feedback presented by Dukan (2014).

Figure 4 shows the two reference frames involved. Where the Oculus Rift reference frame is transformed to the body fixed frame of the vehicle.

Figure 5 displays the way the Oculus Rift signal Θ^{oc} first is processed to become the velocity reference ν^{oc}.

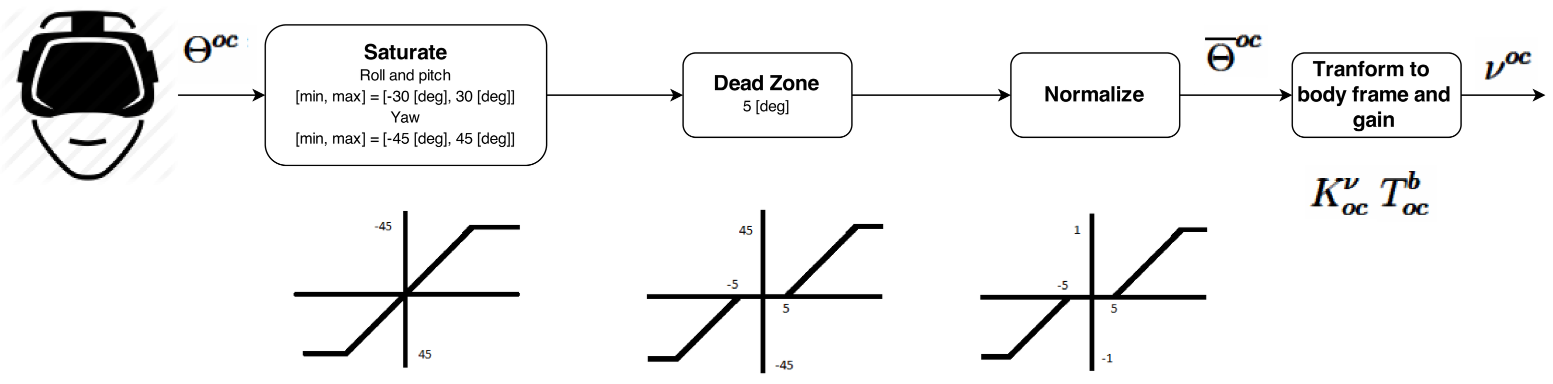

Figure 5: Signal processing for Oculus Rift signals

Software

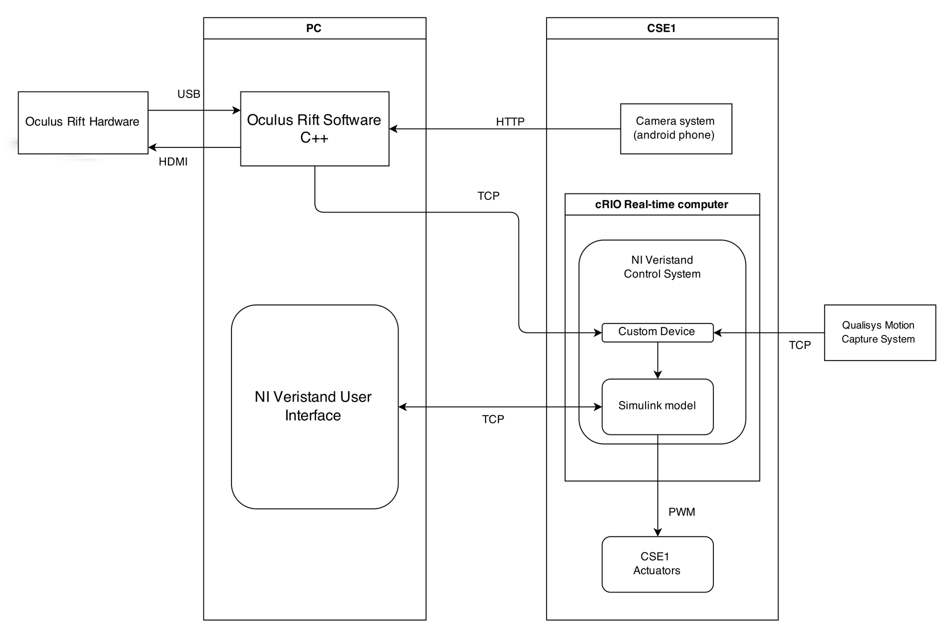

Figure 6: Software Topology for CSE1

Software to handle Oculus Rift is written in C++, the program used in this thesis is a modified version of example code by Davies et al. (2015). The purpose of this program is to show live video from a remote video source on the Oculus Rift, in addition to sending the Oculus Rift sensor data to a control system. Video is processed with the Open Computer Vision (OpenCV) library and a server is set up to send signals over TCP/IP protocol to the control system.

In Figure 6 the software topology for Cybership Enterprise is presented. For the SF 30k control system Oculus Rift was integrated as an input device.

Results

The results presented in Figure 7. show maneuvering of Cybership Enterprise 1 moving in the horizontal plane. For the MC lab trials with CSE1 the goal for the operator was to move around a floating object marked as a circle in the plot. A Youtube video of the MC lab model scale tests are available by Valle (2015) (or use the QR-code).

Full scale test with ROV was conducted and in Figure 8 the ROV is conducting a square maneuver with position control using speed reference from the Oculus Rift. As seen in the plot the ROV is managing the maneuver well.

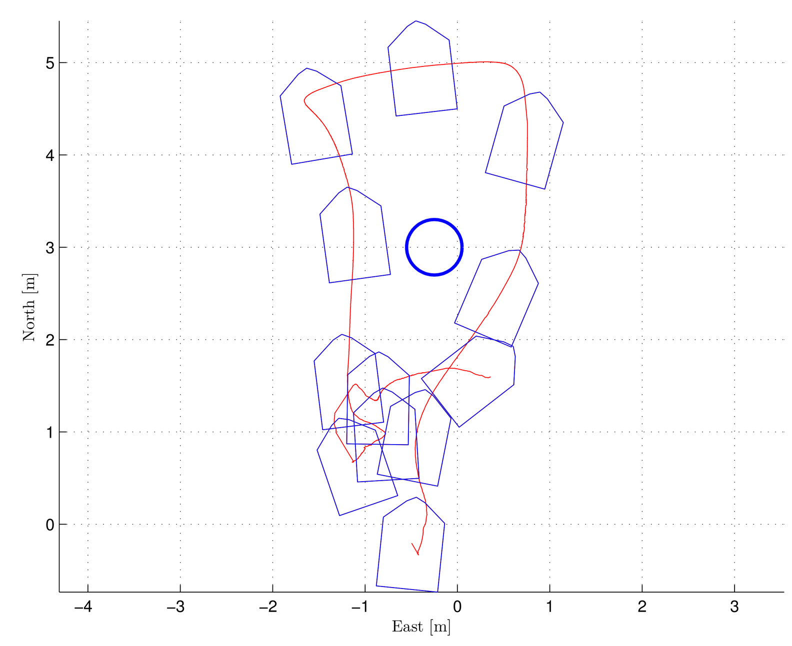

Figure 7: Model scale results from Cybership Enterprise 1

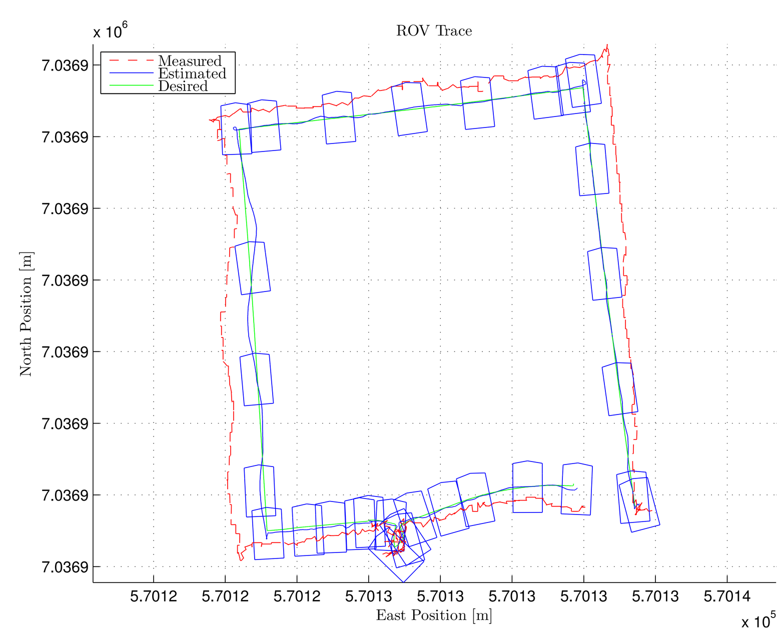

Figure 8: Full scale results from ROV SF 30k

Conclusions

A marine telepresence system have been implemented on Cybership Enterprise 1 and the SF 30k. It has been shown that it is possible to maneuver the vessels with Oculus Rift as an input device.

References

Davies, B. A., Bryla, K. & Benton, A. (2015), *Oculus Rift In Action*, Manning Publications Co.

Dukan, F. (2014), 'Rov motion control systems'.

Fossen, T. I. (2011), *Handbook of marine craft hydrodynamics and motion control*, John Wiley & Sons.

Oculus, V. (2014), *Oculus Developer Guide, SDK Version 0.4*, Oculus VR, LCC.

Skåtun, H. N. (2011), 'Development of a dp system for cs enterprise i with voith schneider thrusters'.

Valle, E. (2015), 'Oculus rift ship control'. [Accessed on May 24, 2015].
URL: *https://youtu.be/rZd_HcvvDUw*